6.2 *Simulation Case 2: Airport Scenario with 40% Spectrum Overlap*

In the second simulation case a typical airport scenario is considered. In the vicinity of a larger airport one expects much higher aircraft density than in the cross-country case. For that reason the cells of the two systems are sectorized. The approach adopted for sectrization follows standard guidelines for terrestrial cellular systems. Each omni-directional base station is replaced by three sectors. The sectors use 120-degree antennas with standard azimuthal orientations of 0, 120 and 240 degrees. The maximum gain of the utilized antennas is 12dBi and their horizontal and vertical pattern are presented in Fig. 25. As can be seen, in the horizontal plane, the pattern of the antenna is of an ideal shape with a beamwidth of 121 degrees. The one-degree overlap allows smooth handoff transition between adjacent sectors. In the vertical plane, the pattern is the same as the one used in the omni-directional case. Therefore, the antennas have an uptilt of four degrees, vertical 3dB beamwidth of 6.3 degrees and the 'null fills'.

When changing the system configuration from omni-directional to sectorized, the capacity of the system is increased. Theoretically, and for ideal antenna patterns, each sector can handle the same number of calls as an omni-directional cell. Therefore, at least theoretically, the sectorization of a cell into three 120 degrees sectors produces a threefold increase in the system's capacity. This increase, expressed in the number of aircraft for different loading scenarios is summarized in Table 6. As seen, in the sectorized case, in the typical scenario of 50% pole point loading, each of the two systems can support approximately 24 aircraft.

Table 6. Mapping between loading and the total number of aircraft per system – sectorized configuration of airport scenario

Loading [%]	Number of aircraft
25	12
50	24
75	36

Keeping the same general simulation parameters summarized in Table 2, the KPI of the sectorized systems for three different loading scenarios are evaluated.

The results of the simulations are presented in Figs 26 to 35.

Figures 27 to 35 demonstrate that for 25% and 50% loading, the sectorization produces the desired results. The capacity of the system is tripled without a significant increase in the cross system interference. At 50% loading, the system is capable of supporting the capacity of 24 aircraft while maintaining relatively small SINR degradations. As seen from Figs 28 and 31, when the loading is smaller than 50%, the probability of SINR degradation larger than 1dB is kept below 1.3%. Therefore as long as the system is operating below 50% loading, the cross system interference is negligible.

For loading larger than 50%, the cross system interference increases gradually. When the number of aircraft is large, the chance of a "close encounter" over relatively small geographical region around the airport increases and hence there are more events of cross-interference.

Due to the random motion of the aircraft, their distribution over the market area is non-uniform. The non-uniformity in the distribution drives some of the sectors closer to the pole point and to the steep region of the noise rise curve [3]. For that reason, both the mean and the standard deviation of the aircraft transmit power become larger. The combination of the above given effects leads to a rapid degradation of the call quality. This is clearly shown in the plots generated for the 75% loading, where it is evident that the aircraft of the both systems spend a large percentage of time transmitting at their maximum PA power. As discussed in the introduction to this section, the transmission at the highest power level is undesirable and a CDMA system should be prevented from operating in this region. Essentially, this means that the system with a high system loading would start suffering from a significant *self-interference* way before it starts causing harmful interference to the other system sharing the ATG spectrum.

The absolute and relative reductions of the forward link throughput in the airport scenario are presented in Fig 35. As seen, the throughput reductions are still very small. In the worst-case scenario of 75% pole point loading, the decrease in the forward link throughput is approximately 2% of its average value. However, from the plots of the reverse link transmit power it is evident that by the time a system reaches the 75% loading, it is already causing an excessive amount of self-interference. For that reason, it is very unlikely that an operator would allow the system to be loaded to the 75% of the pole capacity. In a more typical scenario when the loading is kept below 50%, the cross system interference reduces the average forward link throughput by less than 0.48%. This level of reduction can be considered as insignificant. In 1xEvDO networks, the reverse link is the limiting link and such a small reduction in the forward link data rate is clearly unnoticeable.

For the sake of comparison with other simulation cases, some of the key numerical indicators of the systems performance are summarized in Tables 7 and 8.

Table 7. Probability of experiencing SINR degradation larger than 1dB

Loading [%]	System 1 [%]	System 2 [%]	Average [%]
25	0	0	0
50	0.2	0.2	0.2
75	1.3	1.28	1.29

Table 8. Average reverse link TX power

Loading [%]	System 1 - mean TX power [dBm]	System 2 - mean TX power [dBm]	Average TX power [dBm]
25	2.19	1.81	2.0
50	6.88	6.13	6.51
75	15.83	15.79	15.81

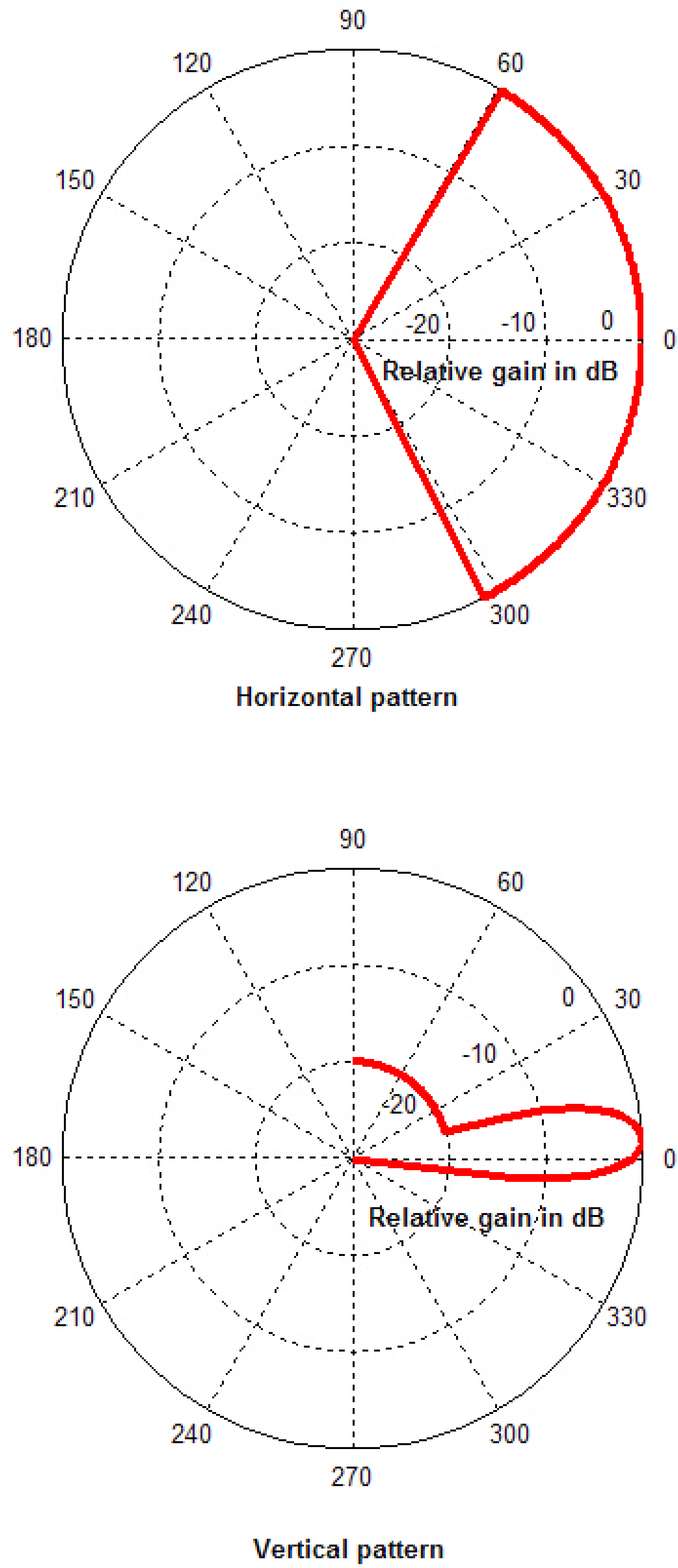
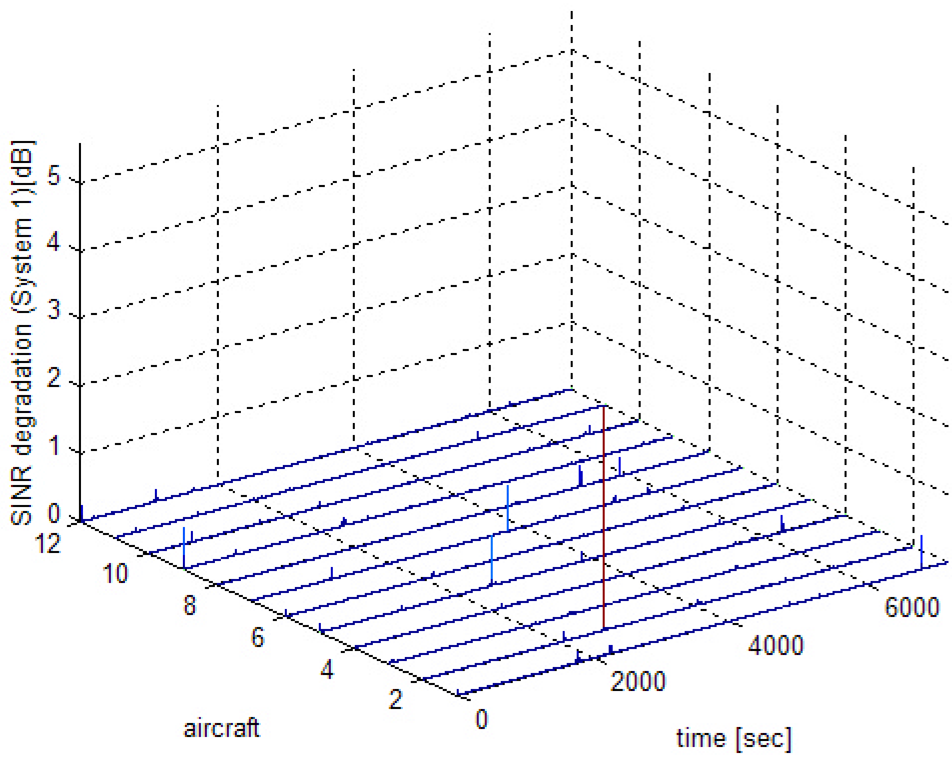


Figure 25. Horizontal and vertical pattern of the antennas used for the sectorized configuration of the cell sites. The maximum absolute gain of the antenna is 12dBi.



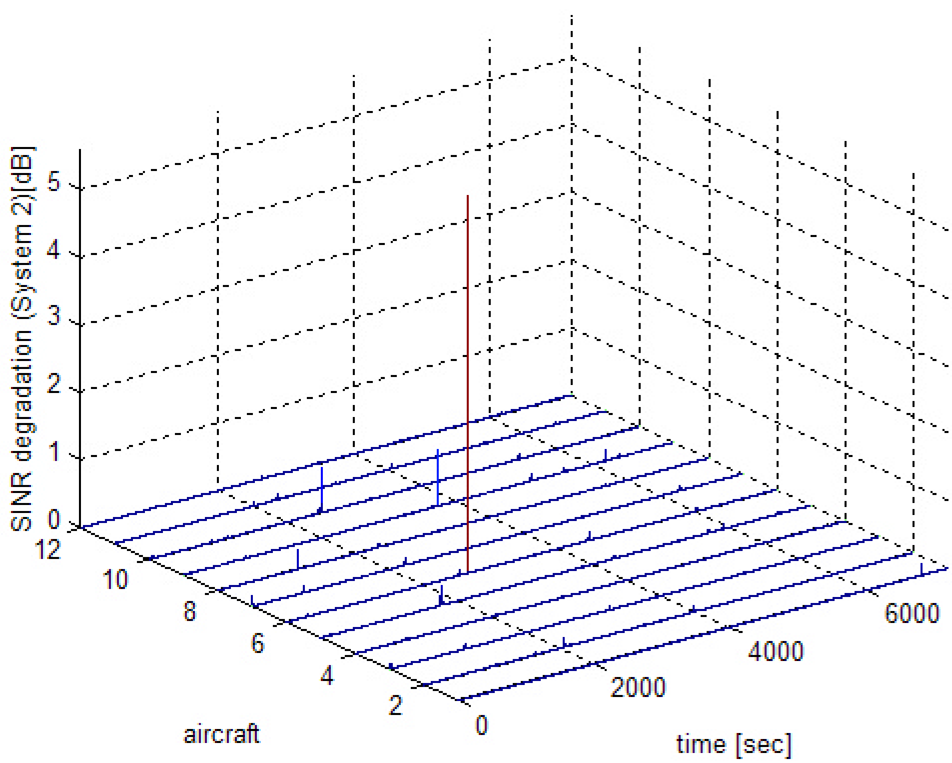
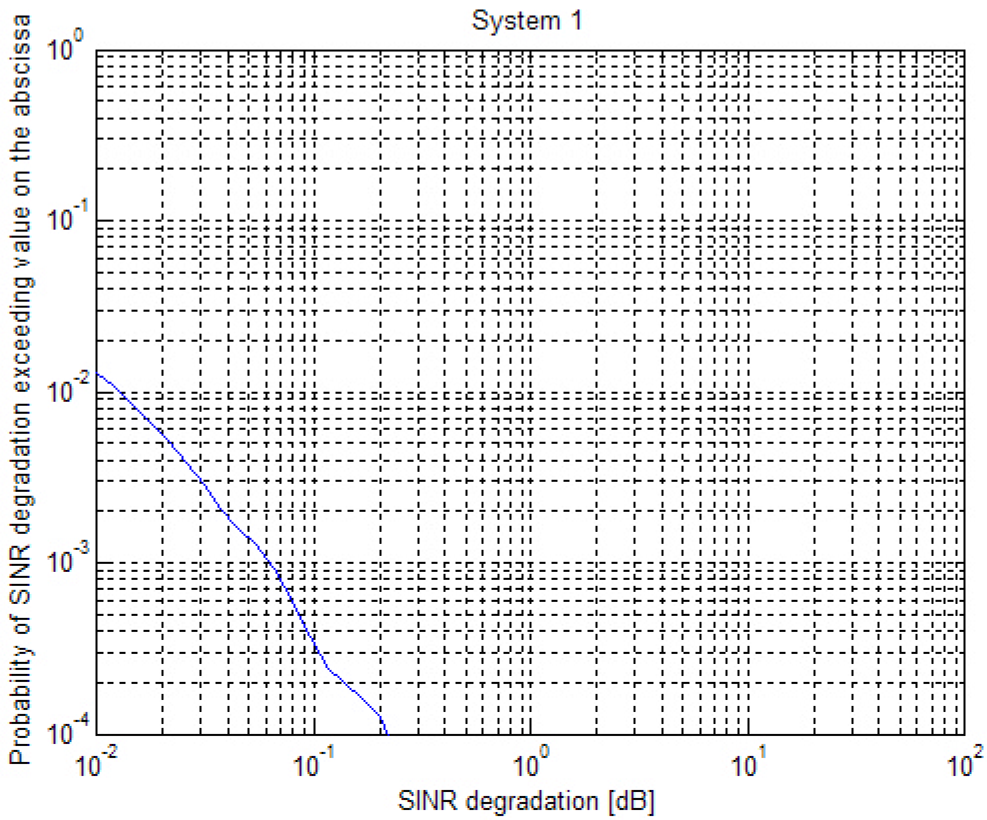


Figure 26. Time domain SINR degradation for airport configuration, 25% pole point loading and 40% spectrum overlap



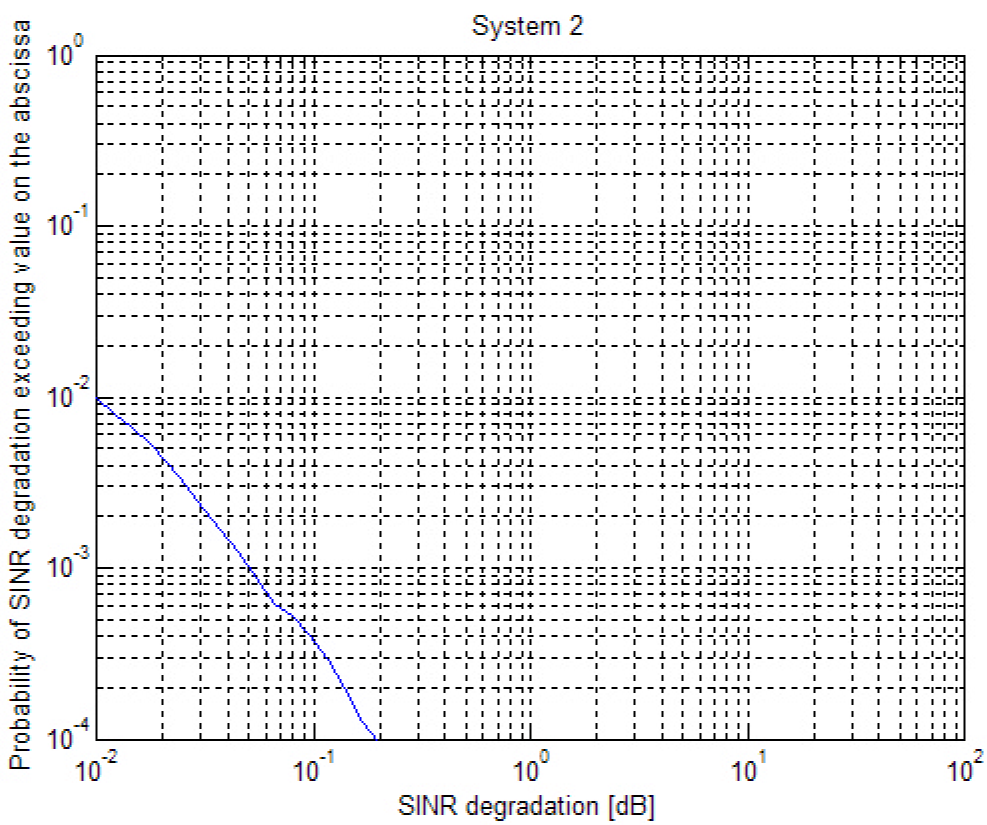


Figure 27. Probability of the SINR degradation for airport configuration, 25% pole point loading and 40% spectrum overlap

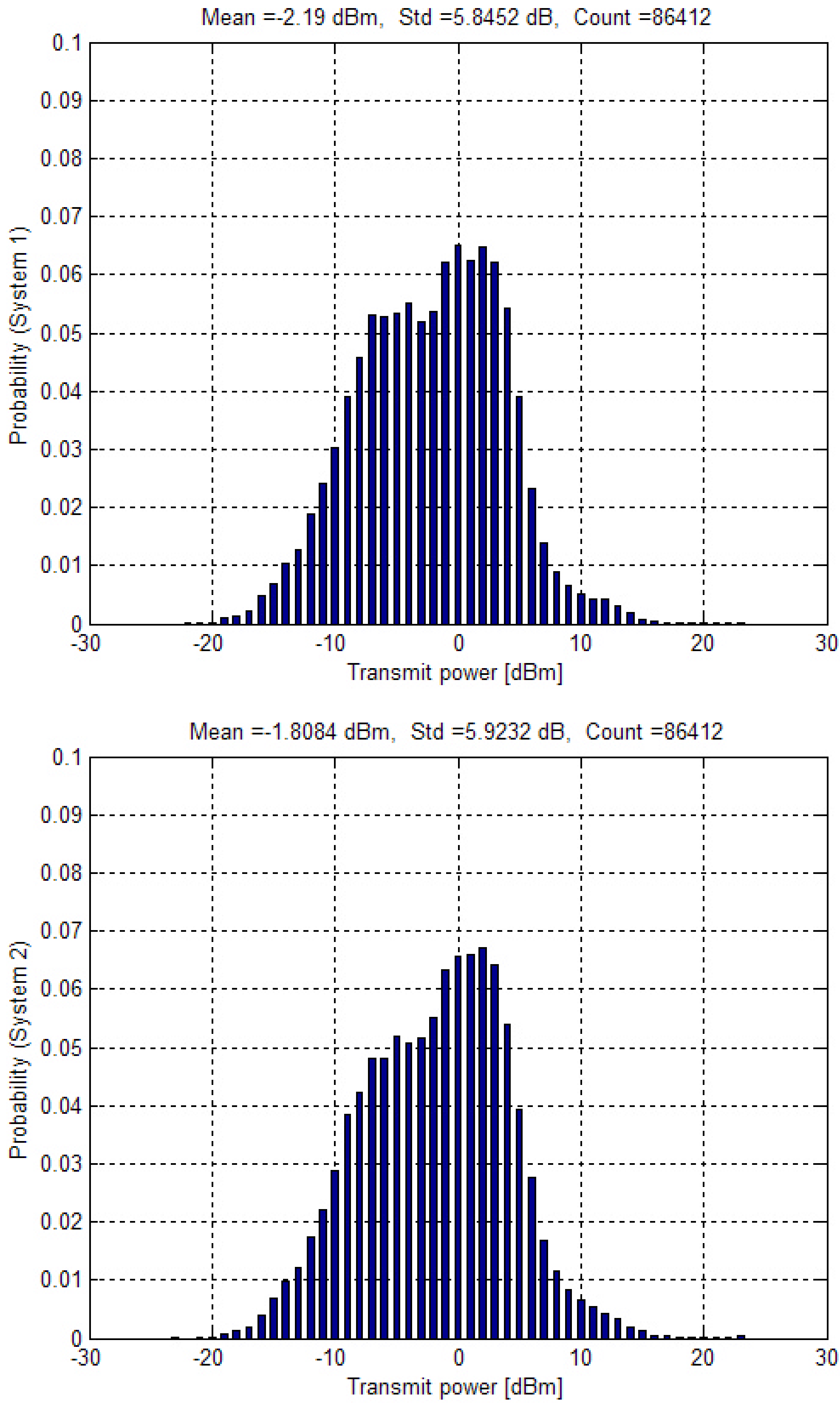


Figure 28. Distribution of the aircraft transmit power for airport configuration, 25% pole point loading and 40% spectrum overlap

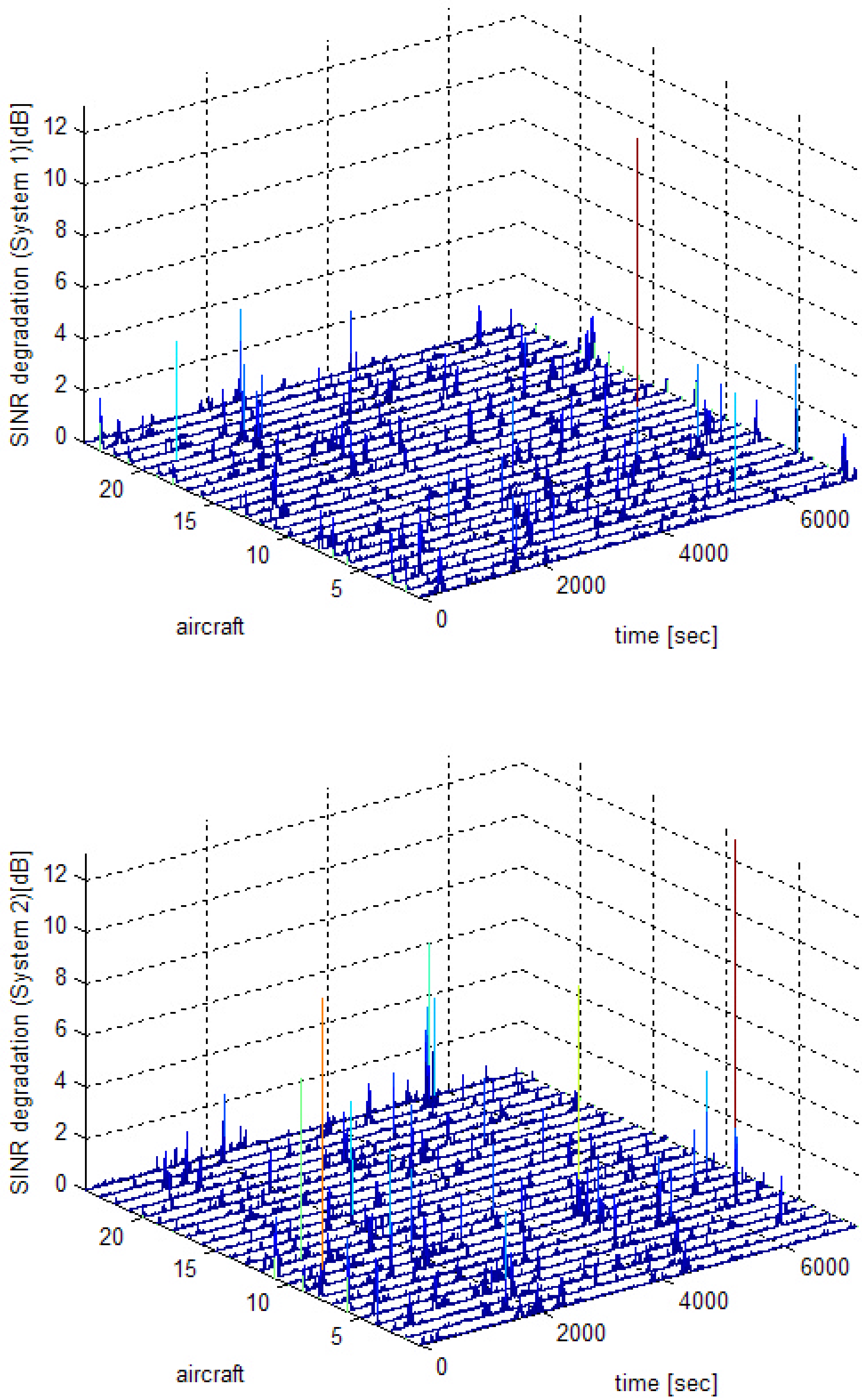


Figure 29. Time domain SINR degradation for airport configuration, 50% pole point loading and 40% spectrum overlap

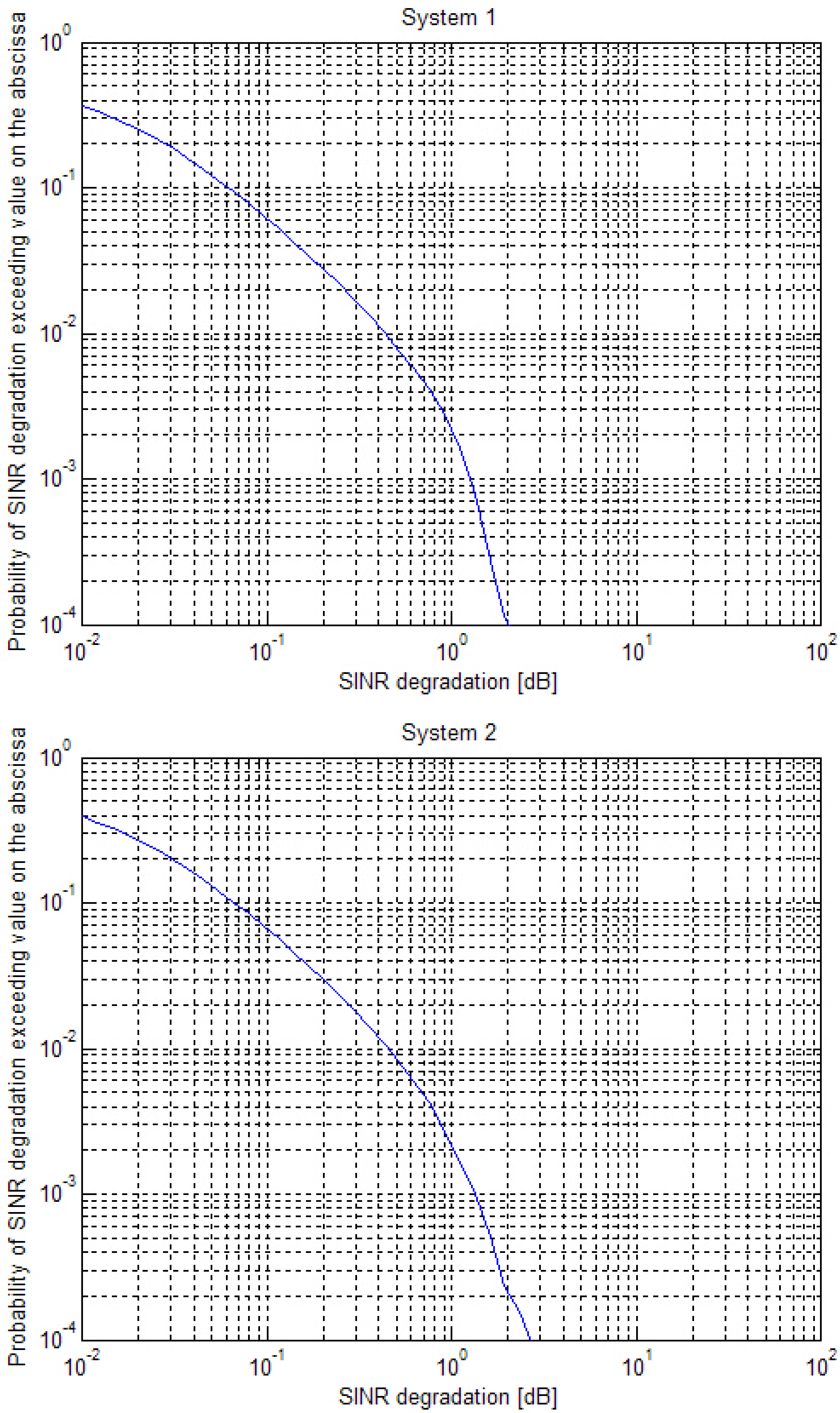


Figure 30. Probability of the SINR degradation for airport configuration, 50% pole point loading and 40% spectrum overlap

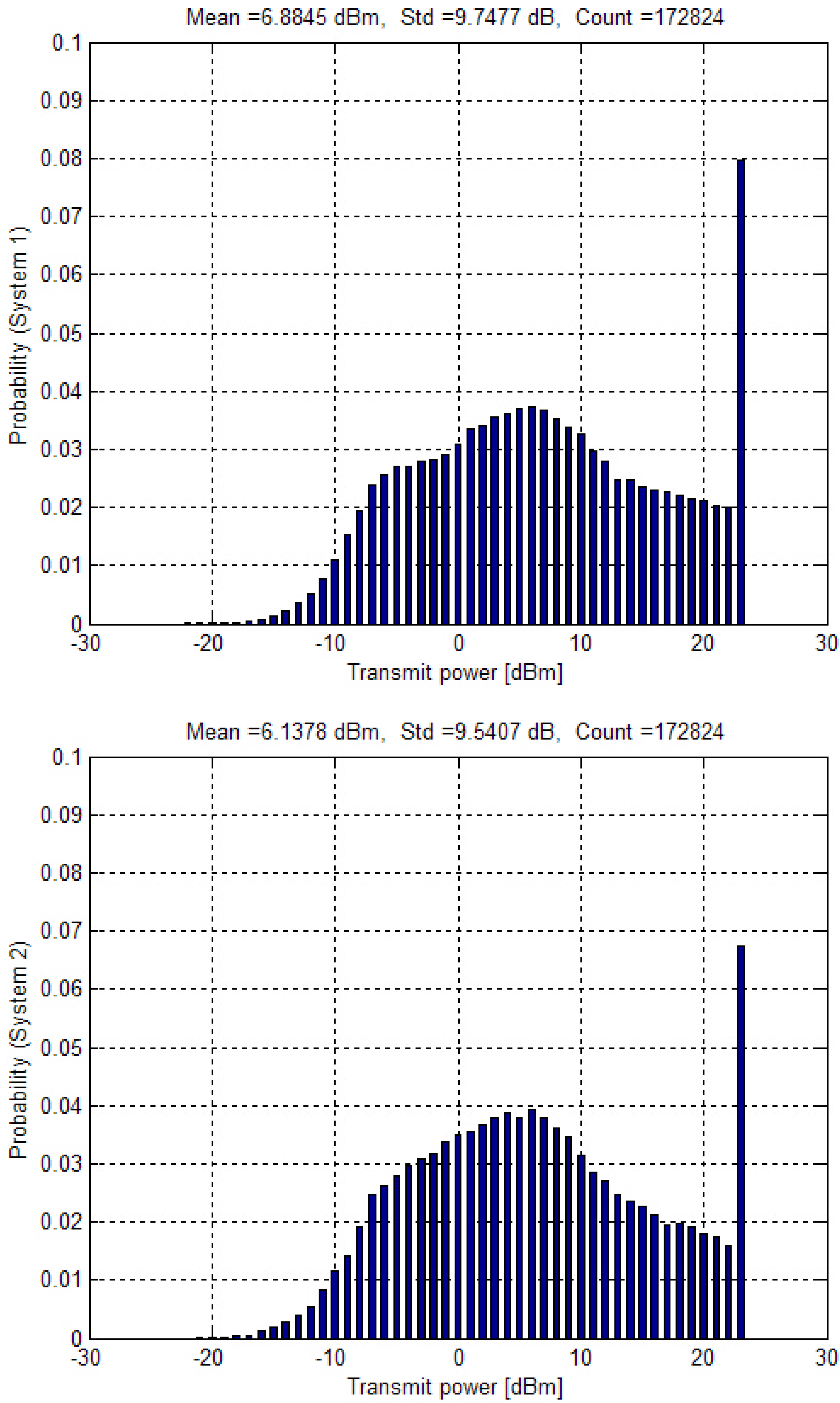
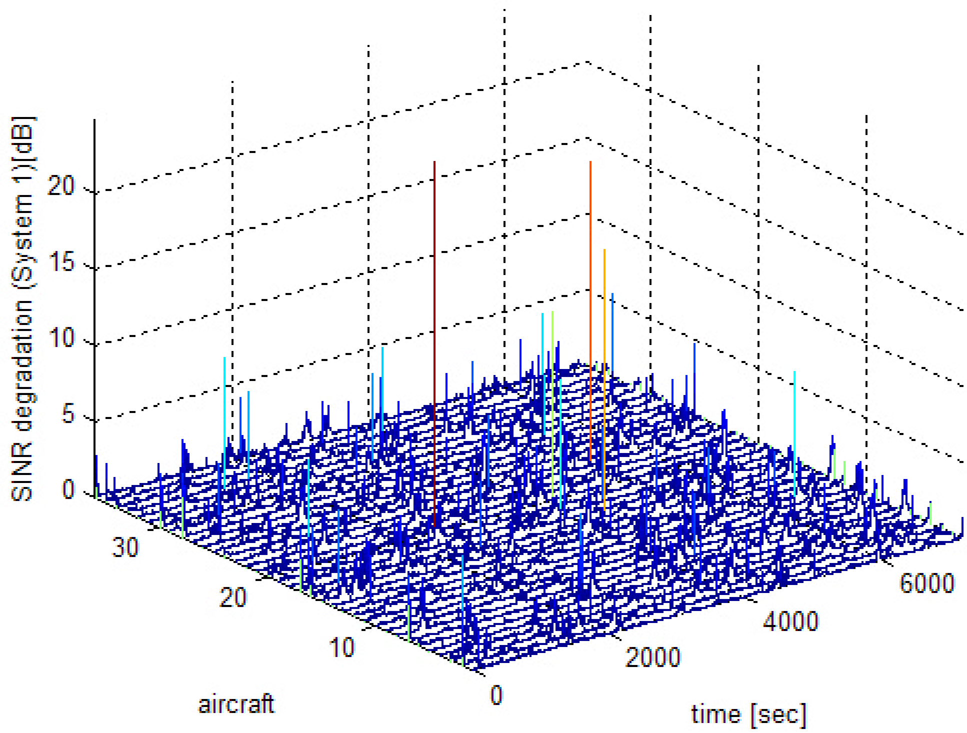


Figure 31. Distribution of the aircraft transmit power for airport configuration, 50% pole point loading and 40% spectrum overlap



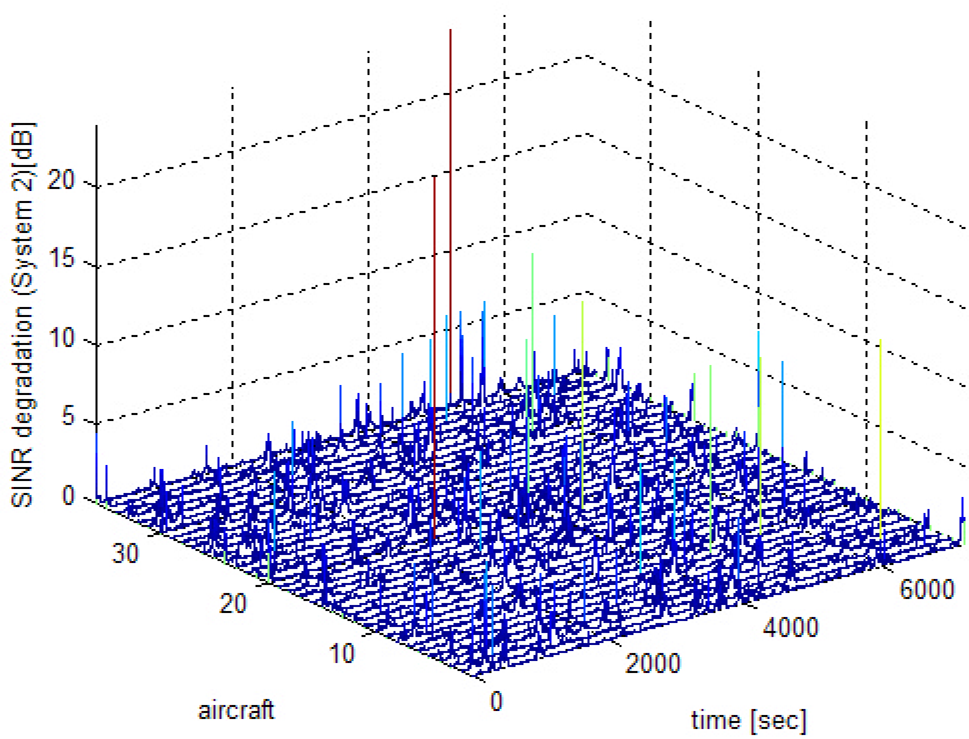


Figure 32. Time domain SINR degradation for airport configuration, 75% pole point loading and 40% spectrum overlap

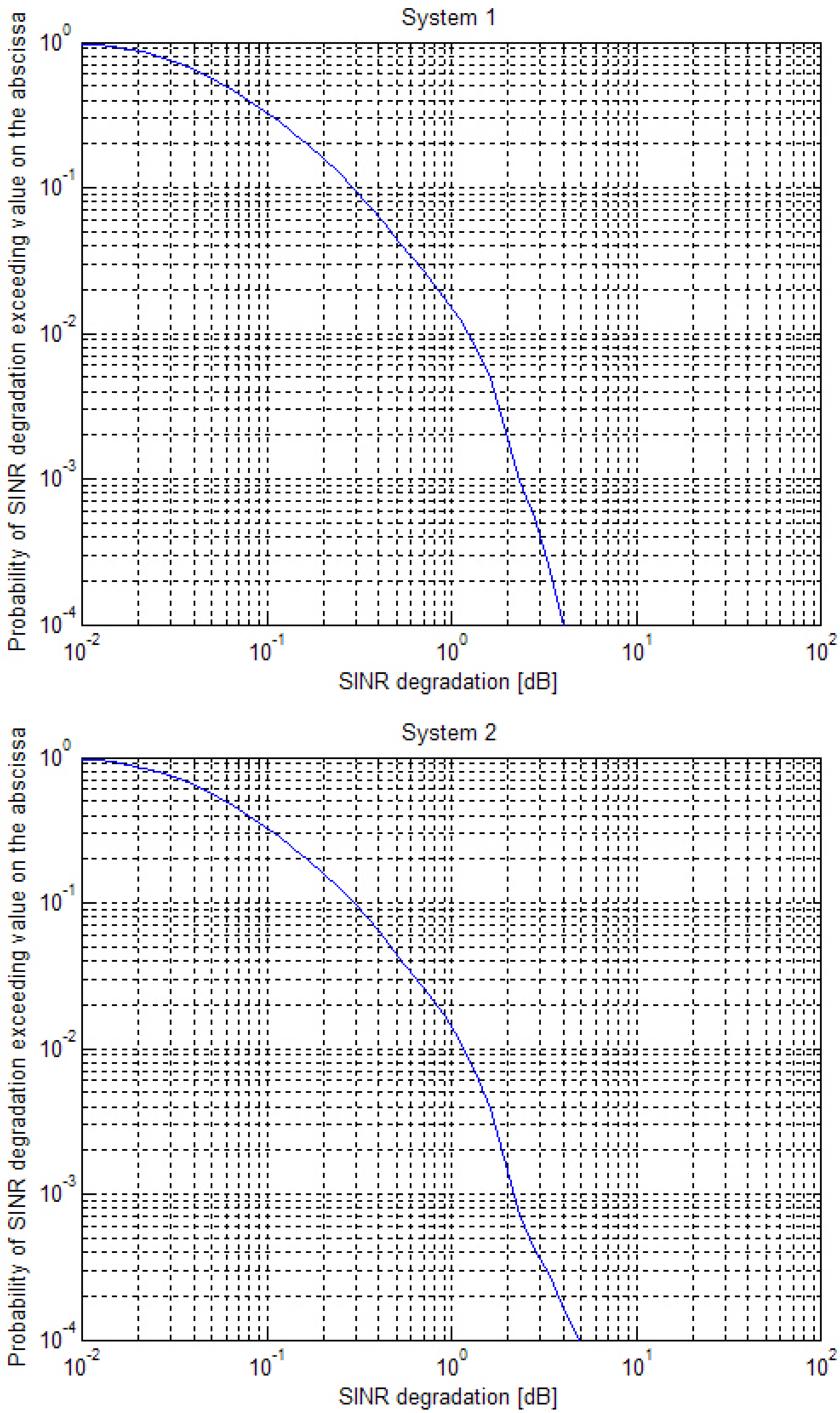
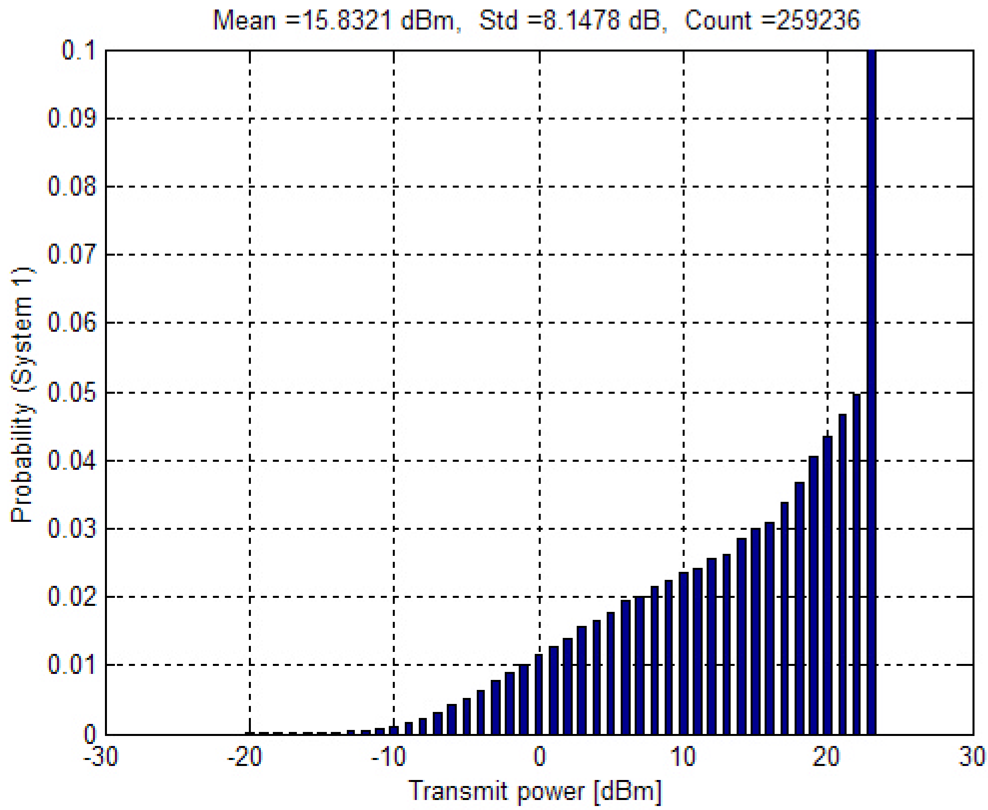


Figure 33. Probability of the SINR degradation for airport configuration, 75% pole point loading and 40% spectrum overlap



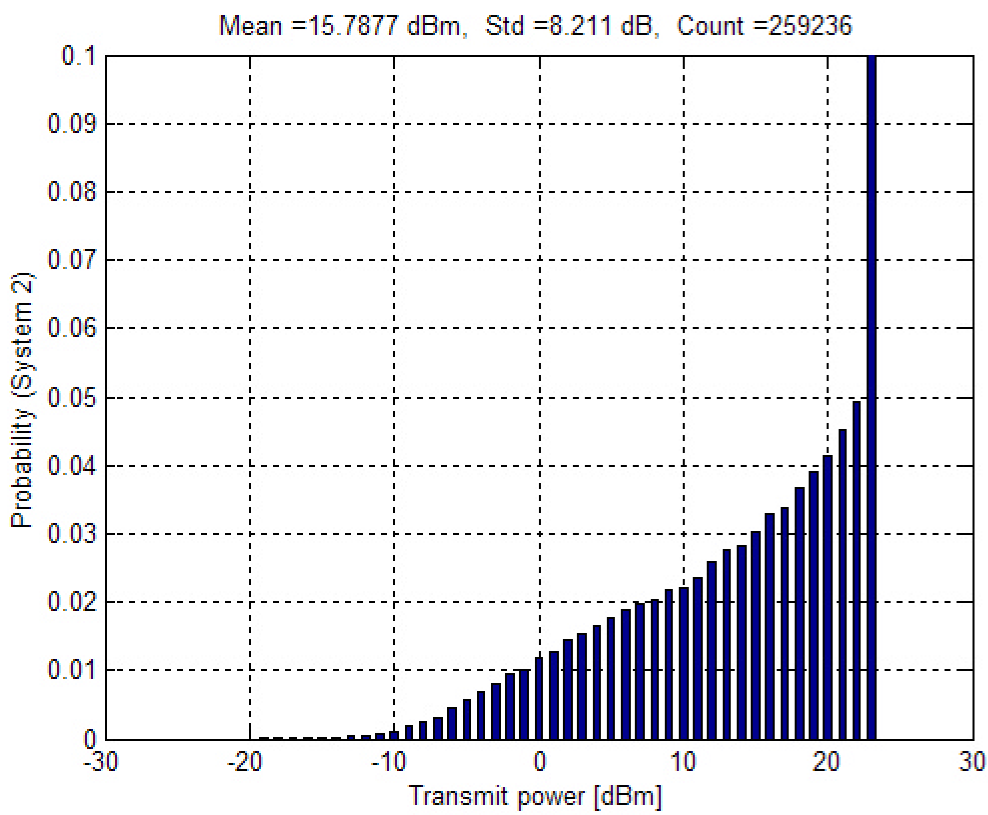


Figure 34. Distribution of the aircraft transmit power for airport configuration, 75% pole point loading and 40% spectrum overlap

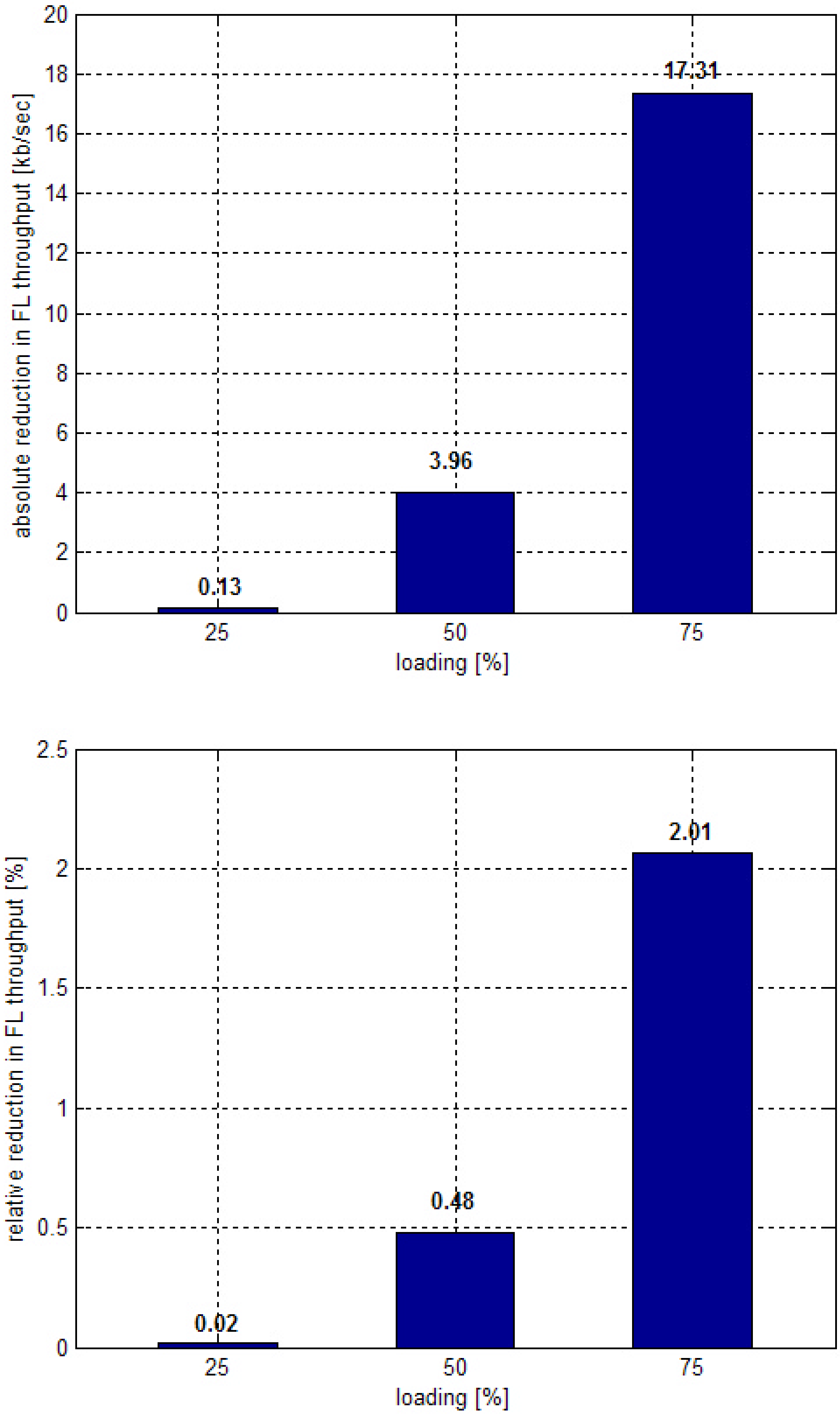


Figure 35. Absolute and relative reduction of FL throughput for the airport system configuration and 40% spectrum overlap